Status Report – Swift Creek Reservoir Watershed Master Plan

Watershed Model Update

Chesterfield County
Planning Commission
Work Session
February 20, 2007

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Goals for Today

- Demonstrate the Following:

  – Independent Verification of TP Load to the Lake

  – Independent Verification of Runoff to the Lake

  – Accuracy of Reckhow's Lake Model for TP Conc.

- Present the Results of the Currently Zoned Load Calculations

- Discuss Next Steps

Load and Flow Verification

- TP Load Verification 1 – Based on PLOAD Model

- TP Load Verification 2 – Reservoir Mass Balance for TP

- Total Flow Verification – Reservoir Water Balance

TP Load Verification 1 – PLOAD

- PLOAD – Annual Pollutant Load Calculation

- Independent Calculation

  - Same Land Use and Impervious Values as P8
  - Other Variables Independent

- 1000 Realization of Model Runs

  - By varying the values of EMC's
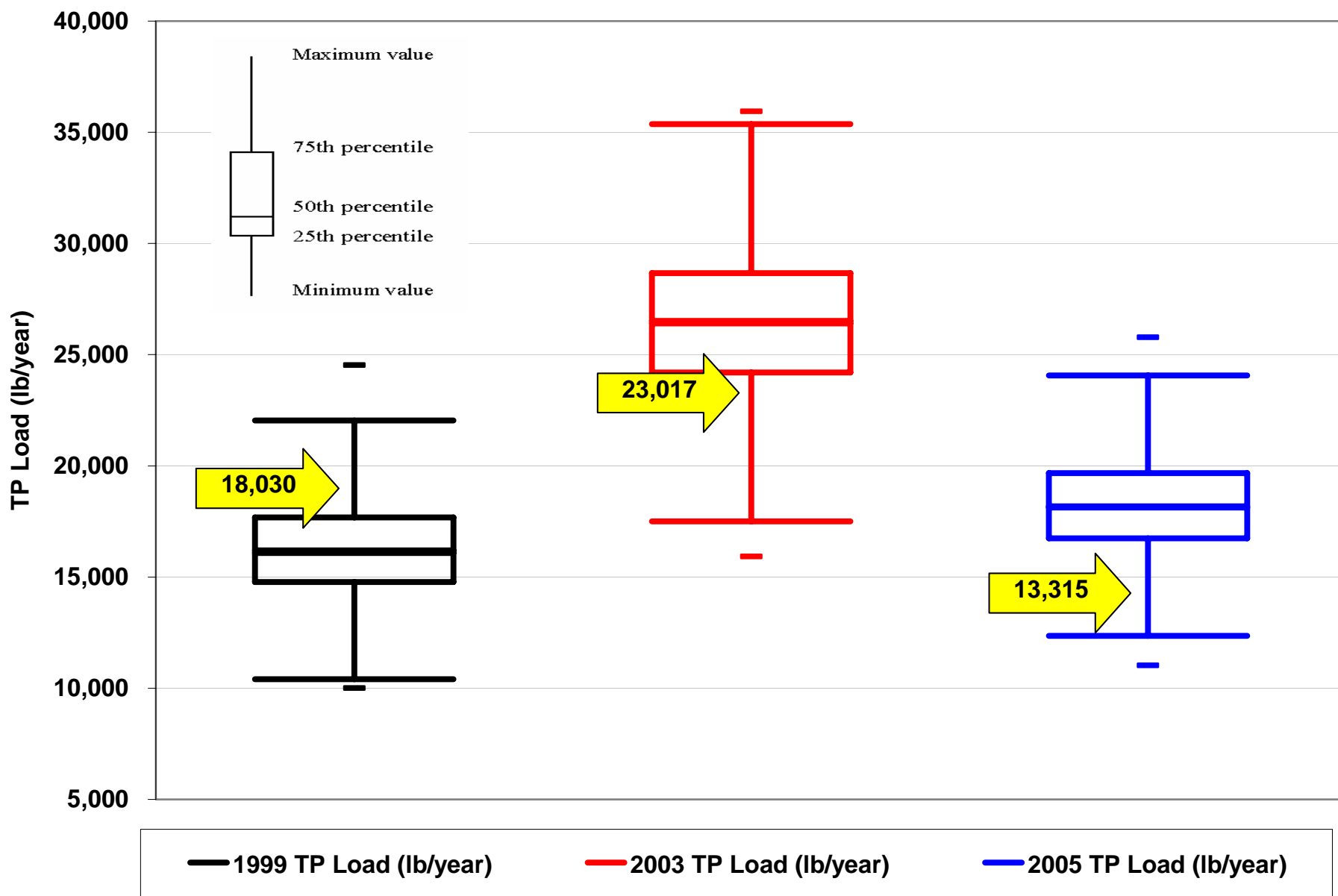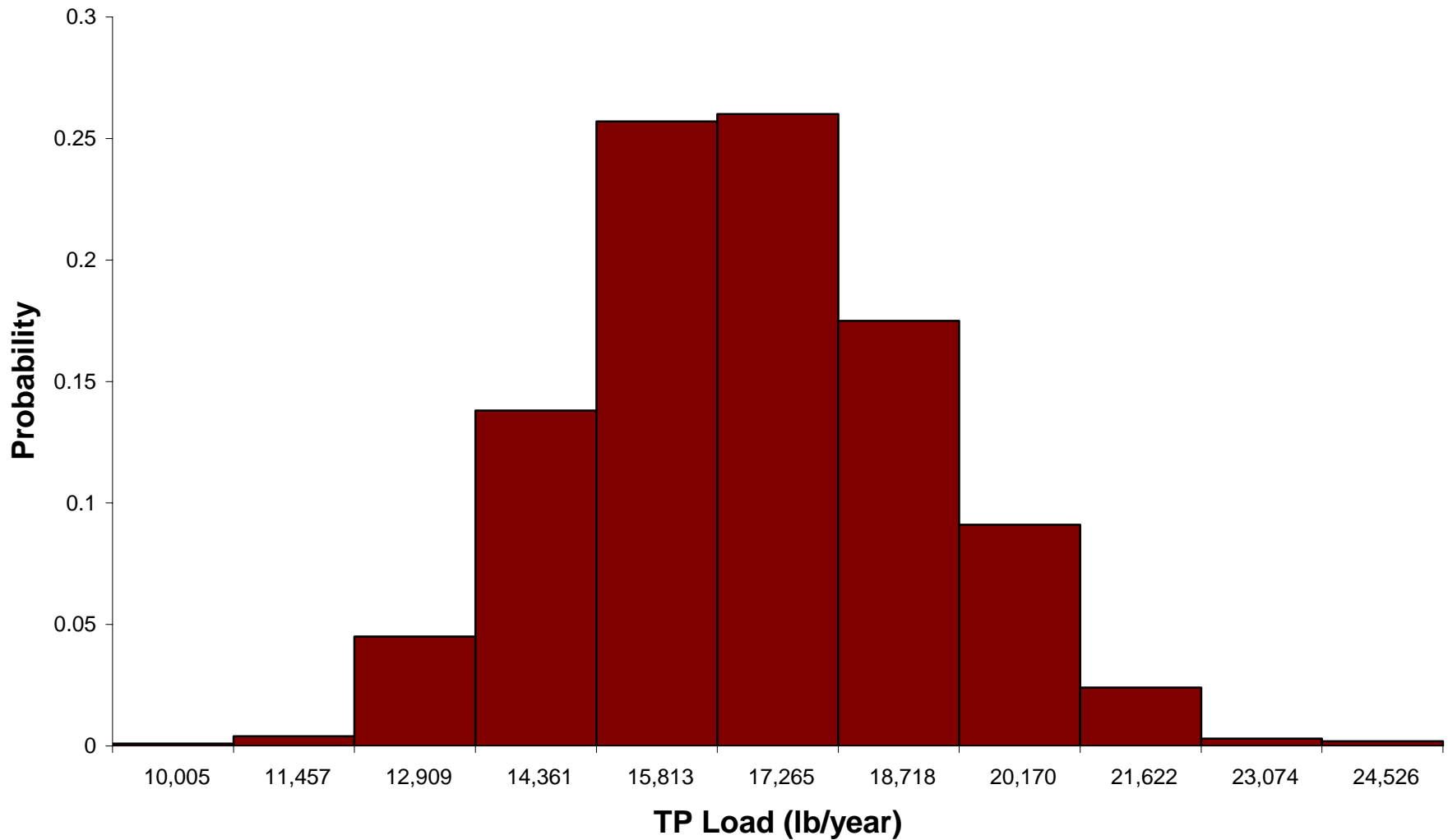 - By varying the fraction of runoff producing storms

TP Load Verification 1 – PLOAD

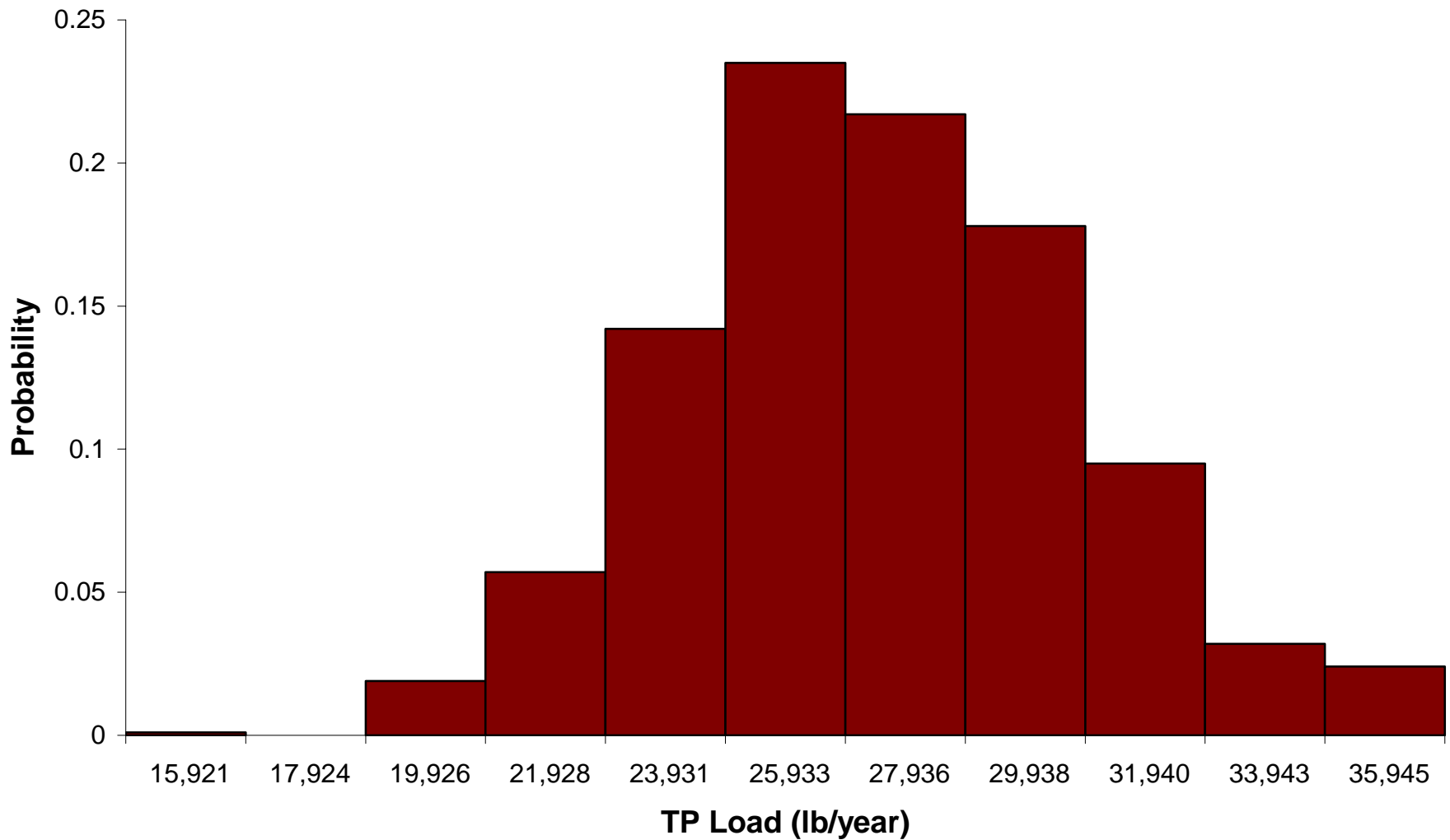| Year	P8 Annual TP Load (lb/yr)	PLOAD Annual Load (lb/yr)	Error
1999	18,030	16,198	11%
2003	23,017	26,404	-15%
2005	13,315	18,123	-36%

- Error varies from -37% to 11%

- 2 of 3 Years within the desired +/-20%

- But, 2003 and 2005 Under Predict with P8
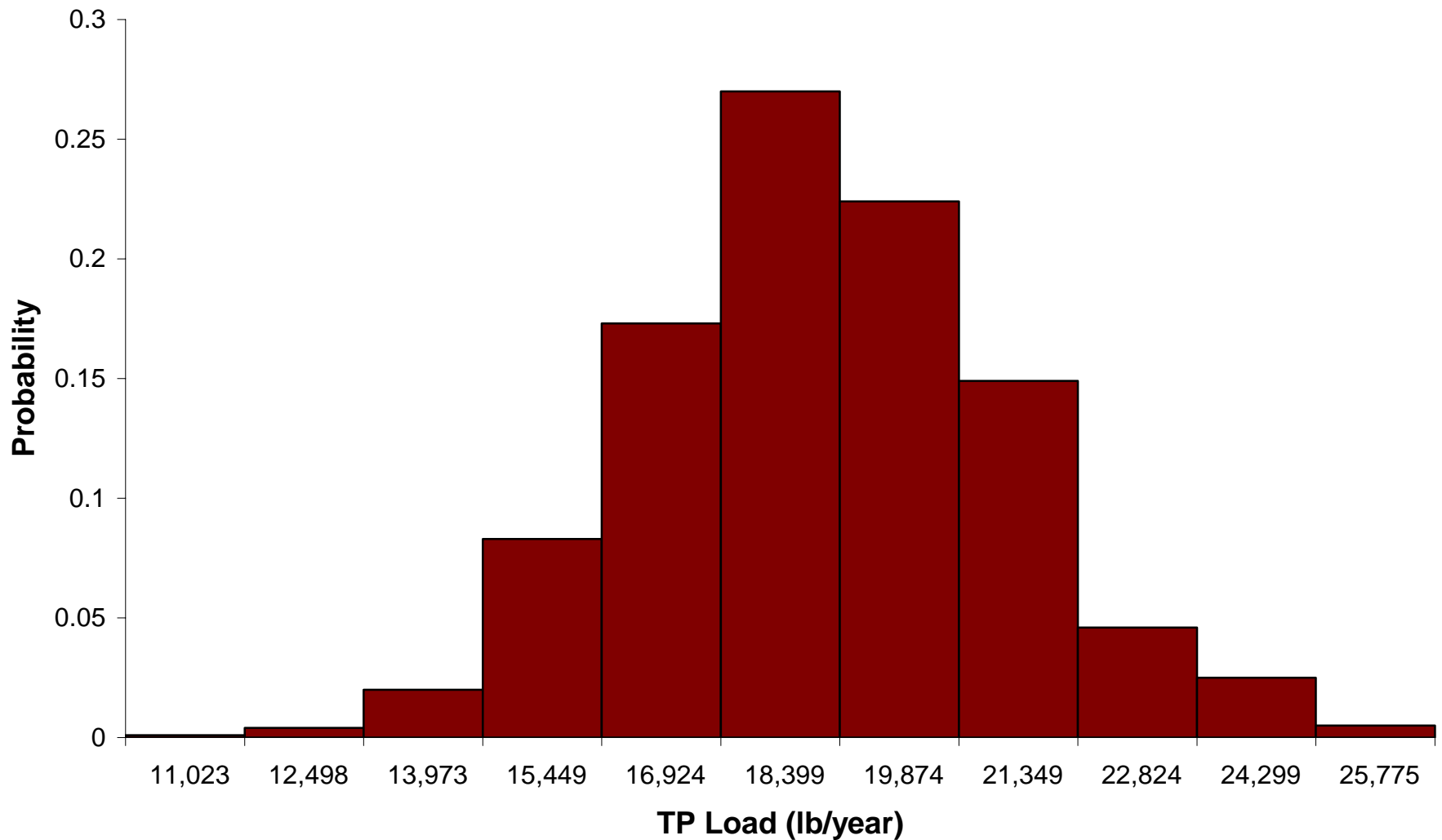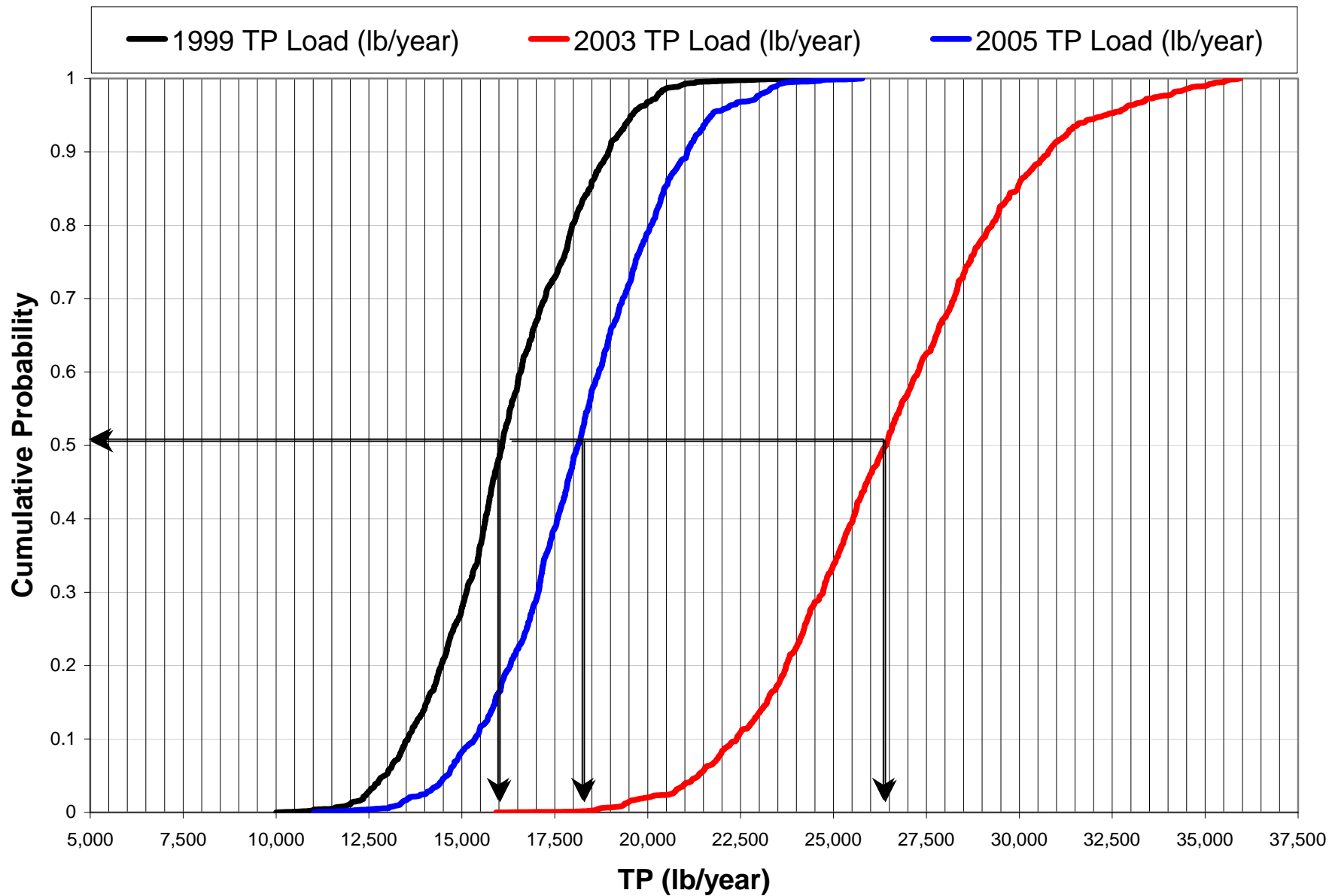
TP Load (lb/year) in 1999

Histogram of TP Load (lb/year) in 1999 with Probability on the y-axis (0 to 0.3) and TP Load (lb/year) on the x-axis ranging from 10,005 to 24,526.

P Load (lb/year) in 2003

TP Load (lb/year)

P Load (lb/year) in 2005

Histogram with y-axis labeled "Probability" ranging from 0 to 0.3, and x-axis labeled "TP Load (lb/year)" with values 11,023; 12,498; 13,973; 15,449; 16,924; 18,399; 19,874; 21,349; 22,824; 24,299; 25,775.

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TP Load Verification 2 – Reservoir Mass Balance

$$V \cdot \frac{dP}{dt} = M_i - M_o - \phi$$

V = lake volume (10^3 m^3)
P = lake phosphorus concentration (mg/l)
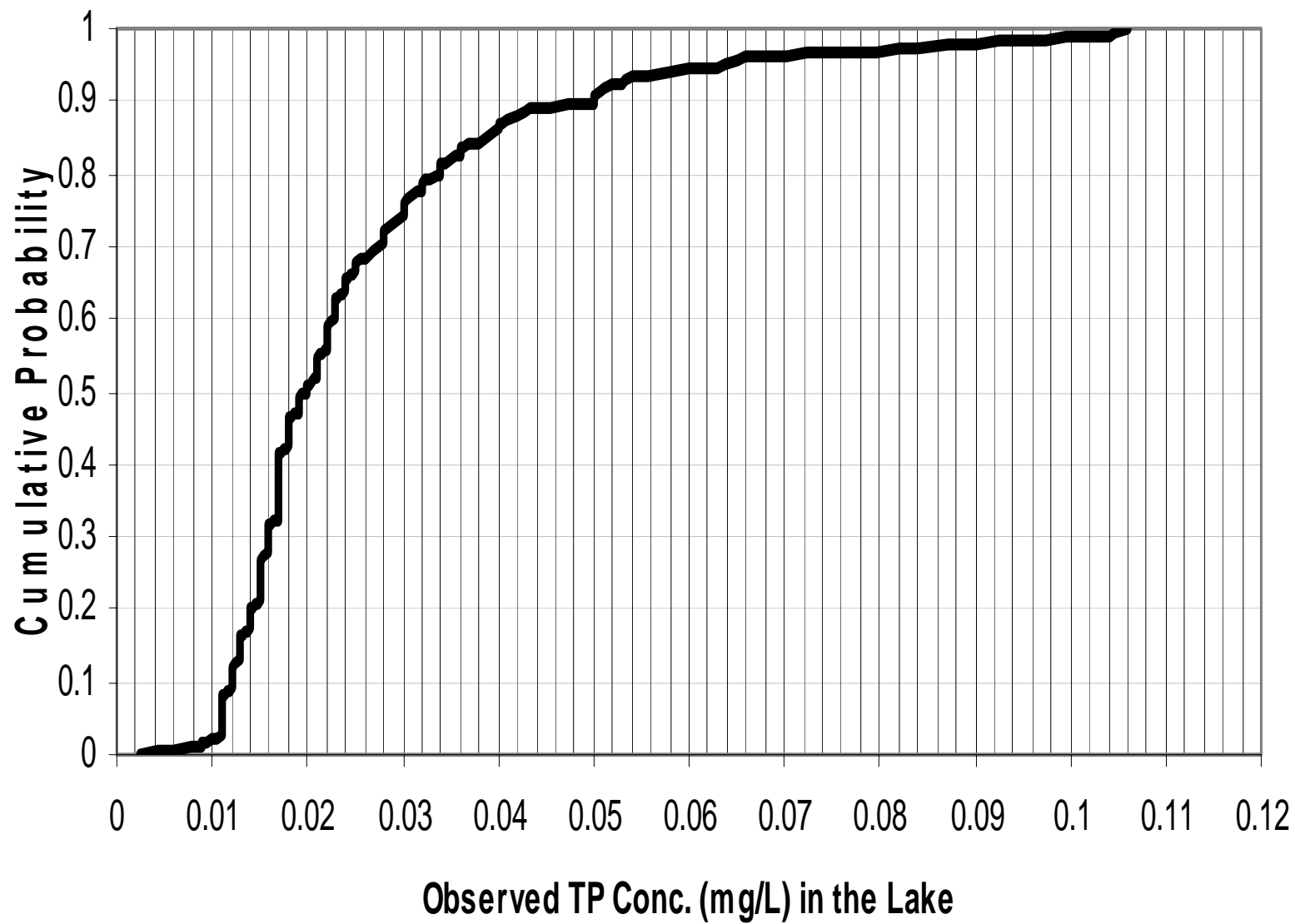M_i = annual mass influx of phosphorus (kg/yr)
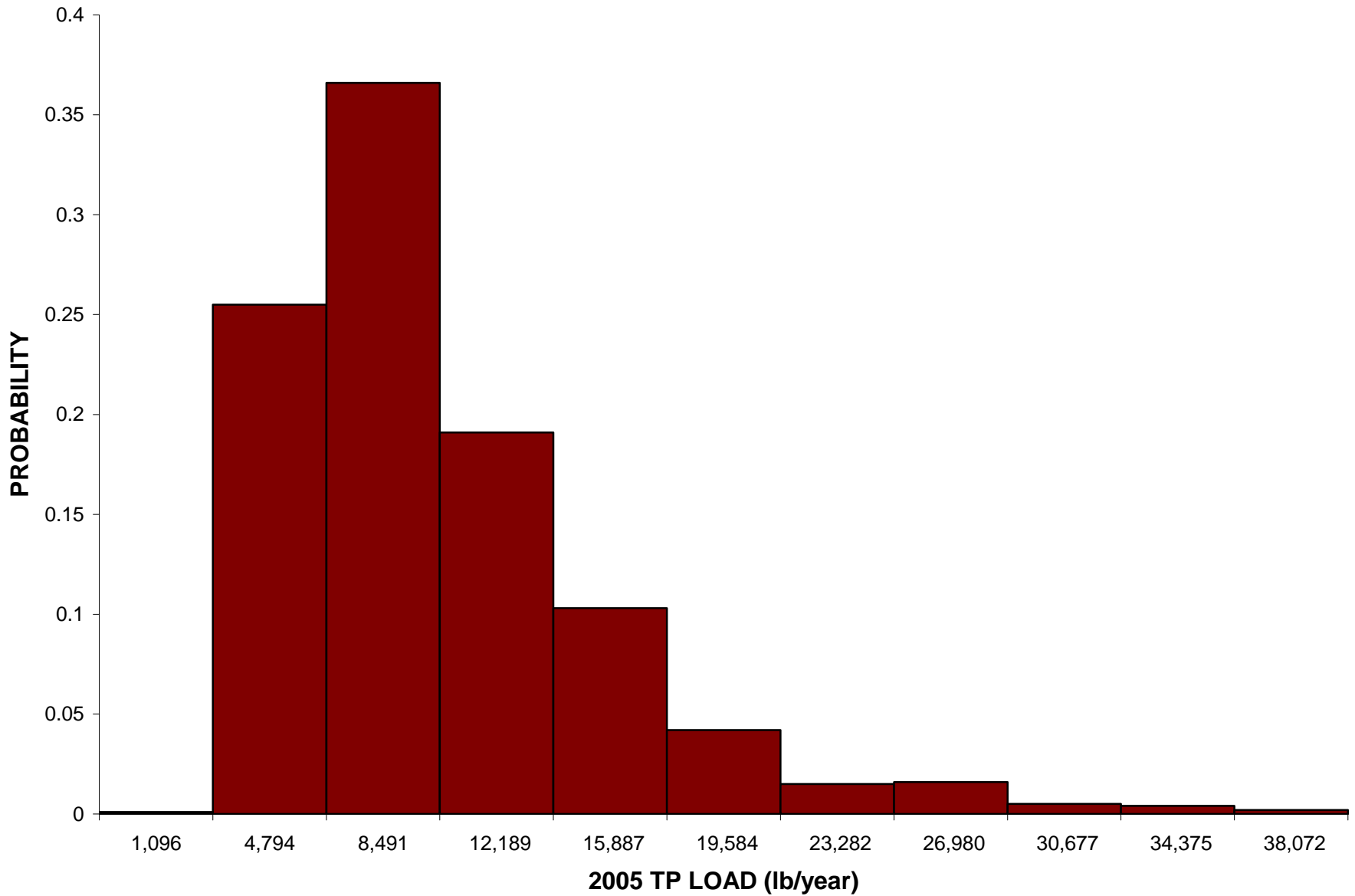M_o = annual mass efflux of phosphorus (kg/yr)
ϕ = annual net flux of phosphorus to the sediments (kg/yr)

- Change in Res. TP Mass = Total Mass In - Total Mass In

- Daily Time Step

- 1,000 Variation Runs of the Mass Balance Model
  - Varying settling velocity
  - Varying TP Concentration
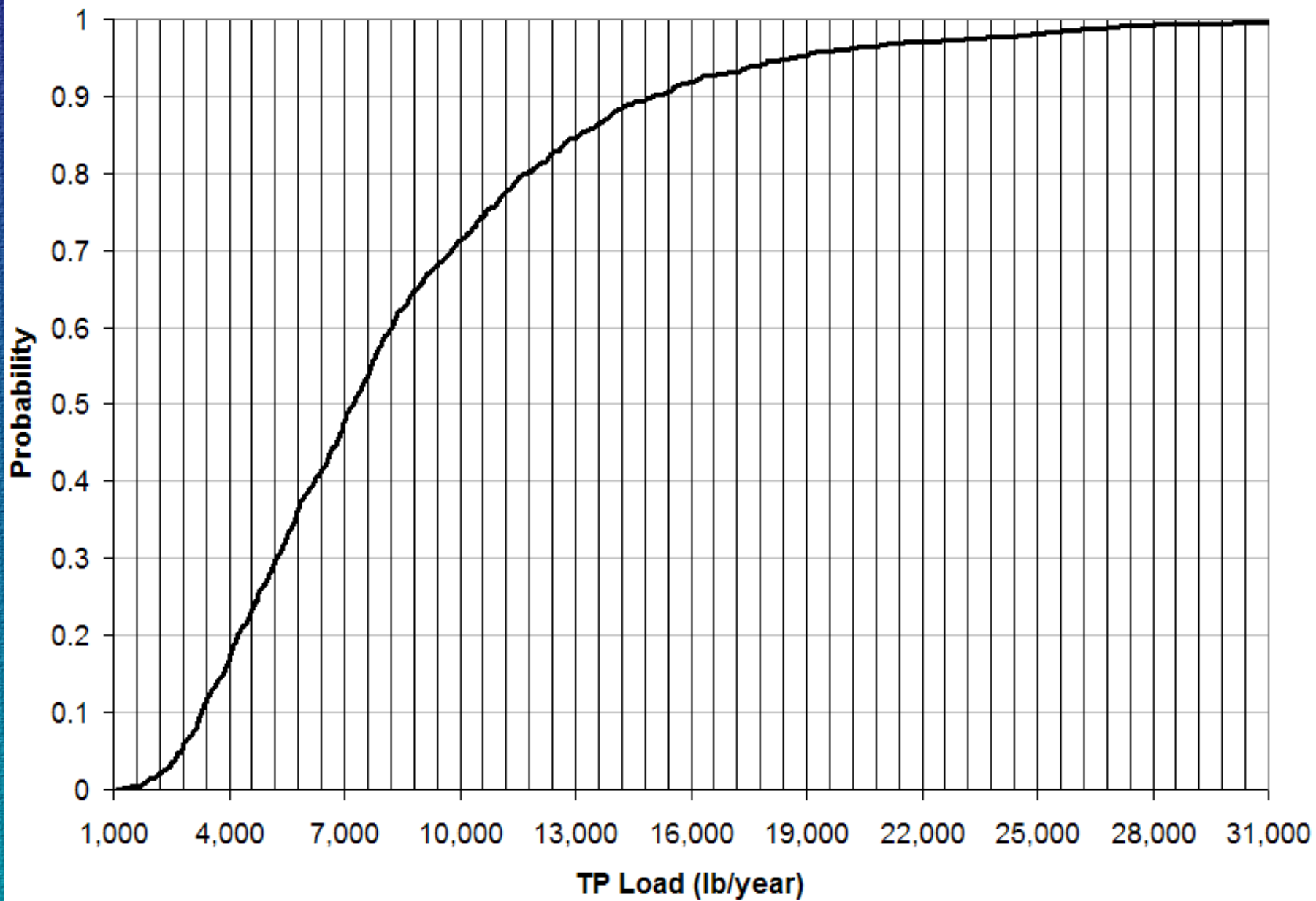- Results similar to TP Load Verification 1

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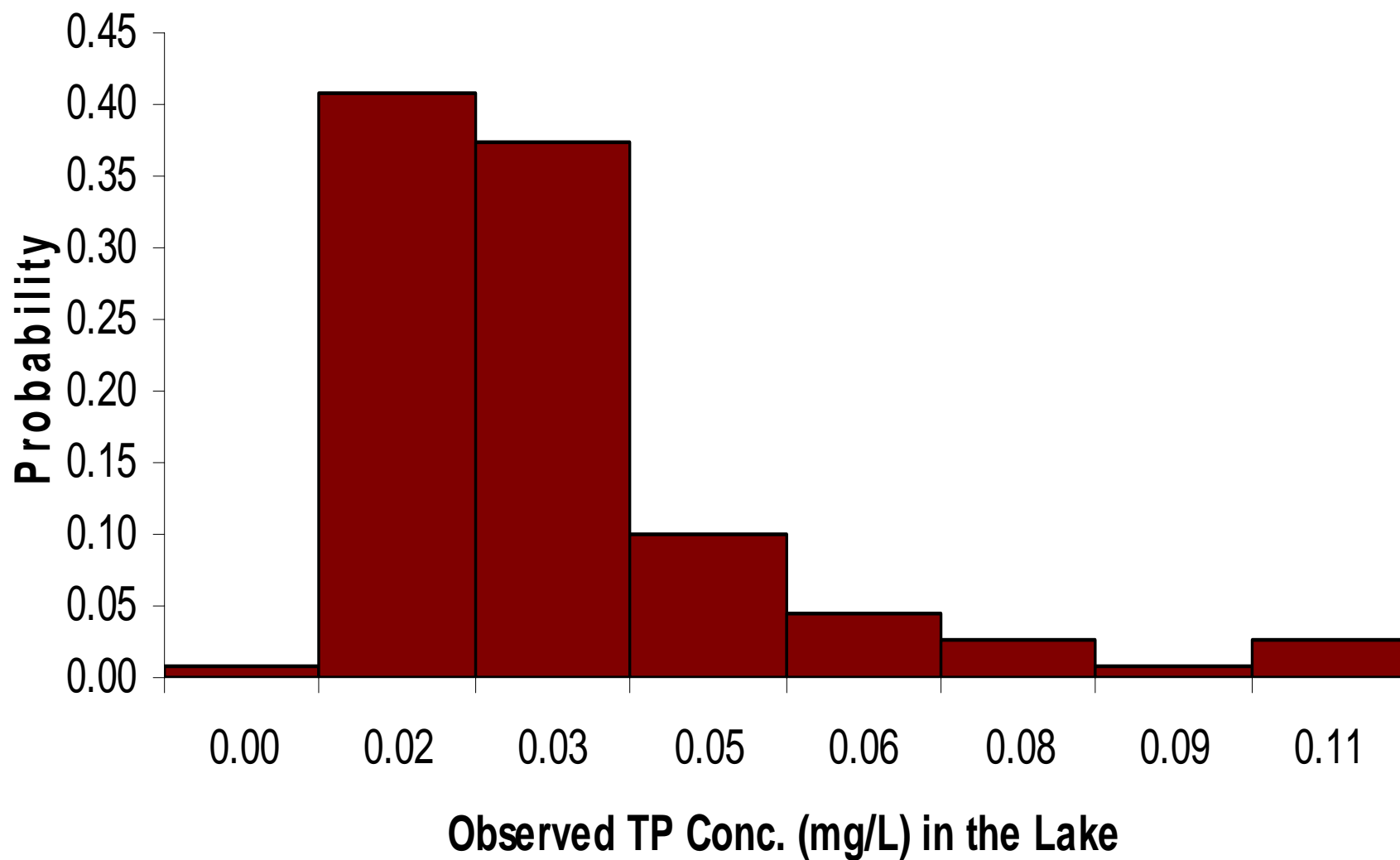
Which Load Verification is More Reliable?

- Mass Balance load based on the actual observed outflow, lake stage, and lake TP concentration data

- PLOAD based load based on event mean concentration values of various land uses from the literature.

- PLOAD based loads are hypothetical that serves as a guideline only and try to give an upper bound of the loads.

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# *Which Load Verification is More Reliable?*

- PLOAD neglects the treatment capacity of natural and man-made treatment facilities in the watershed such as natural ponds, settlement in the channel, and other BMPs.

- Mass-balance based approach accounts all the treatment facilities

- PLOAD is based on the watershed modeling approach whereas the Mass Balance is based on the modeling of TP in the Lake.

Which Load Verification is More Reliable?

- Mass balance is realistic (actual) and PLOAD is hypothetical that works for a generalized watershed when no data is available.

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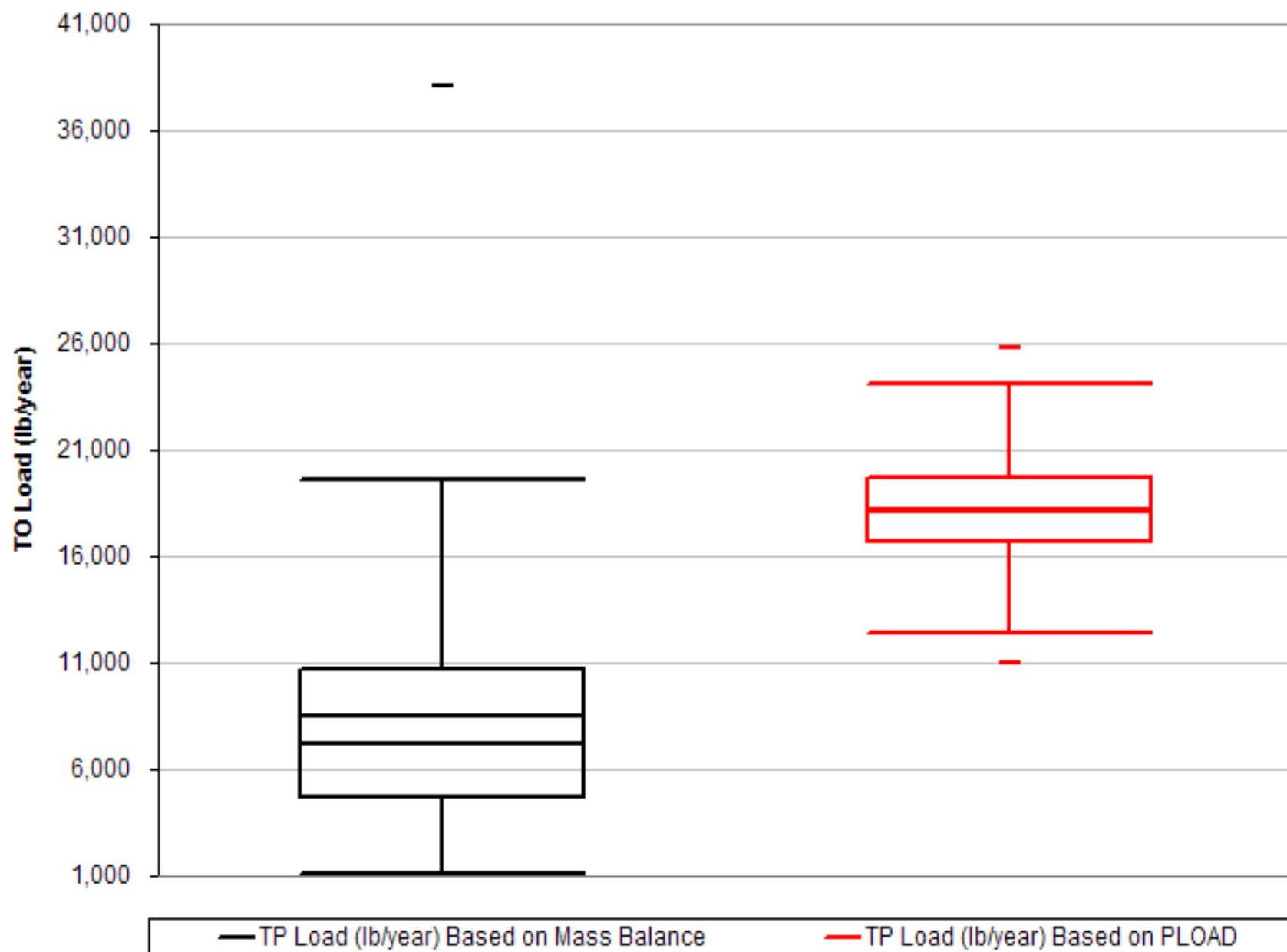
Total Flow Verification – Reservoir Water Balance

- Total Inflow = Total Outflow – Change in Volume

- Total Inflow = $\sum$ Runoff + Direct Rainfall

- Total Outfall = Overflow + Withdrawals + Evaporation

- Daily Time Step

- Data – Rainfall, Evaporation, Reservoir Level

Total Flow Verification – Reservoir Water Balance

- P8 Over Estimated Flow by 38% for 2005

- Consistent with County's Annual Water Balance

Reckhow Model Results

Year	Observed In-Lake TP (mg/L)	In-Lake TP Based On P8 (mg/L)	Error
1999	0.030	0.039	28%
2003	0.032	0.036	13%
2005	0.021	0.027	62%

- Reckhow Model Results
  - Predicted phosphorus levels are within the uncertainty of the models
  - Results can be used planning purposes

Currently Zoned Load Calculations Task

- **Case 1 – All Zoned Parcels**

  - 2005 Land Use

  - Undeveloped Areas that are Zoned for Development

- **Case 2 – All Zoned Parcels and Known Requirements and Proffers**

  - Case 1 Land Use

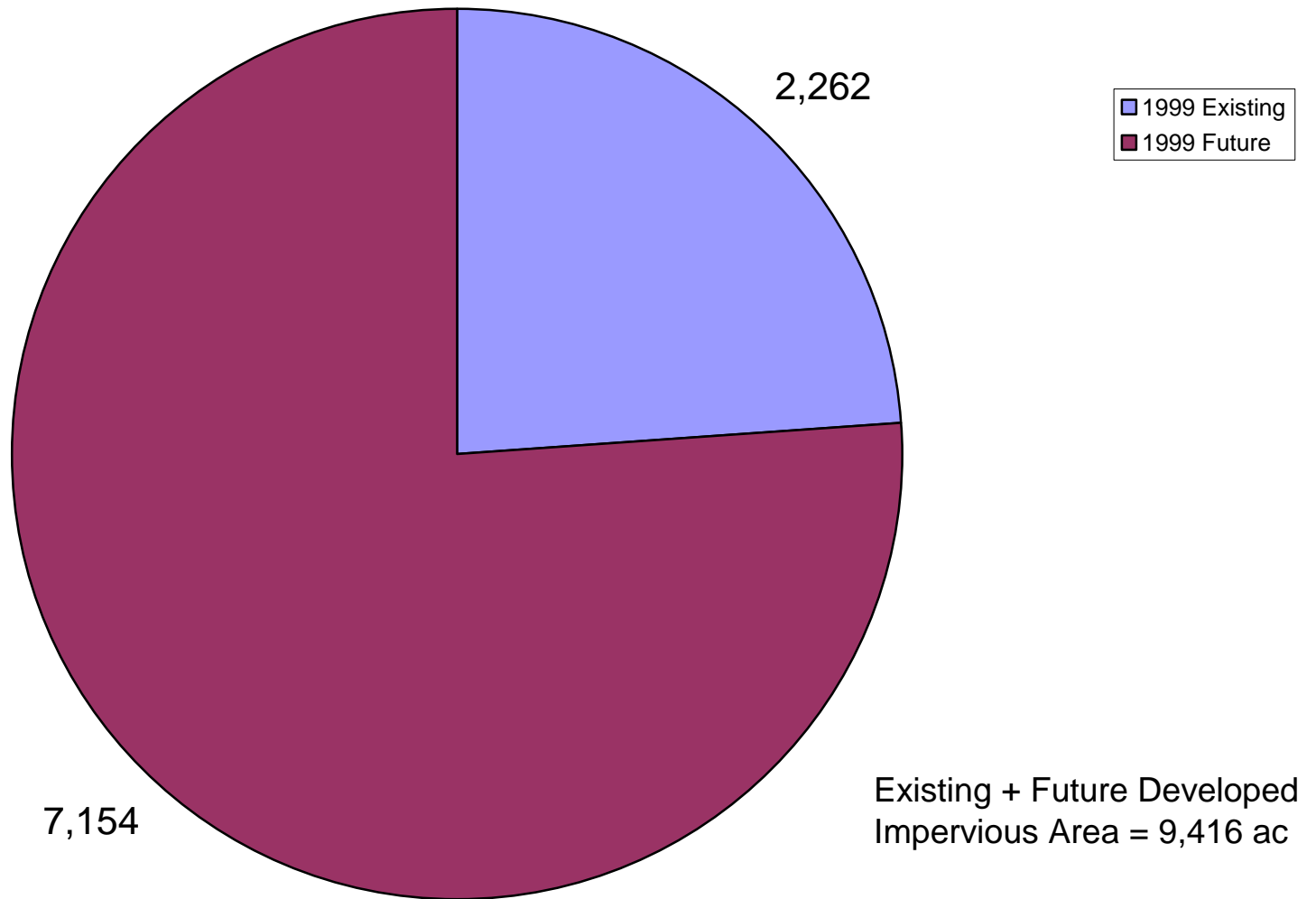 - Adjustments made to P8 input based on water quality loading goals (0.22, 0.3, and 0.45 lb/ac-yr)

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Currently Zoned Load Calculations Task Results

Year	Phosphorus Load (lb/yr)	Runoff Volume (ac-ft/yr)	Median In-Lake TP (mg/L)
Case 1	32,217 (20,900 - 35,400)	96,245	0.060
Case 2	25,078 (15,000 - 27,600)	94,366	0.051

- Both Cases Exceed 0.05 mg/L.

- Case 1 requires a reduction of 7,136 lb/yr

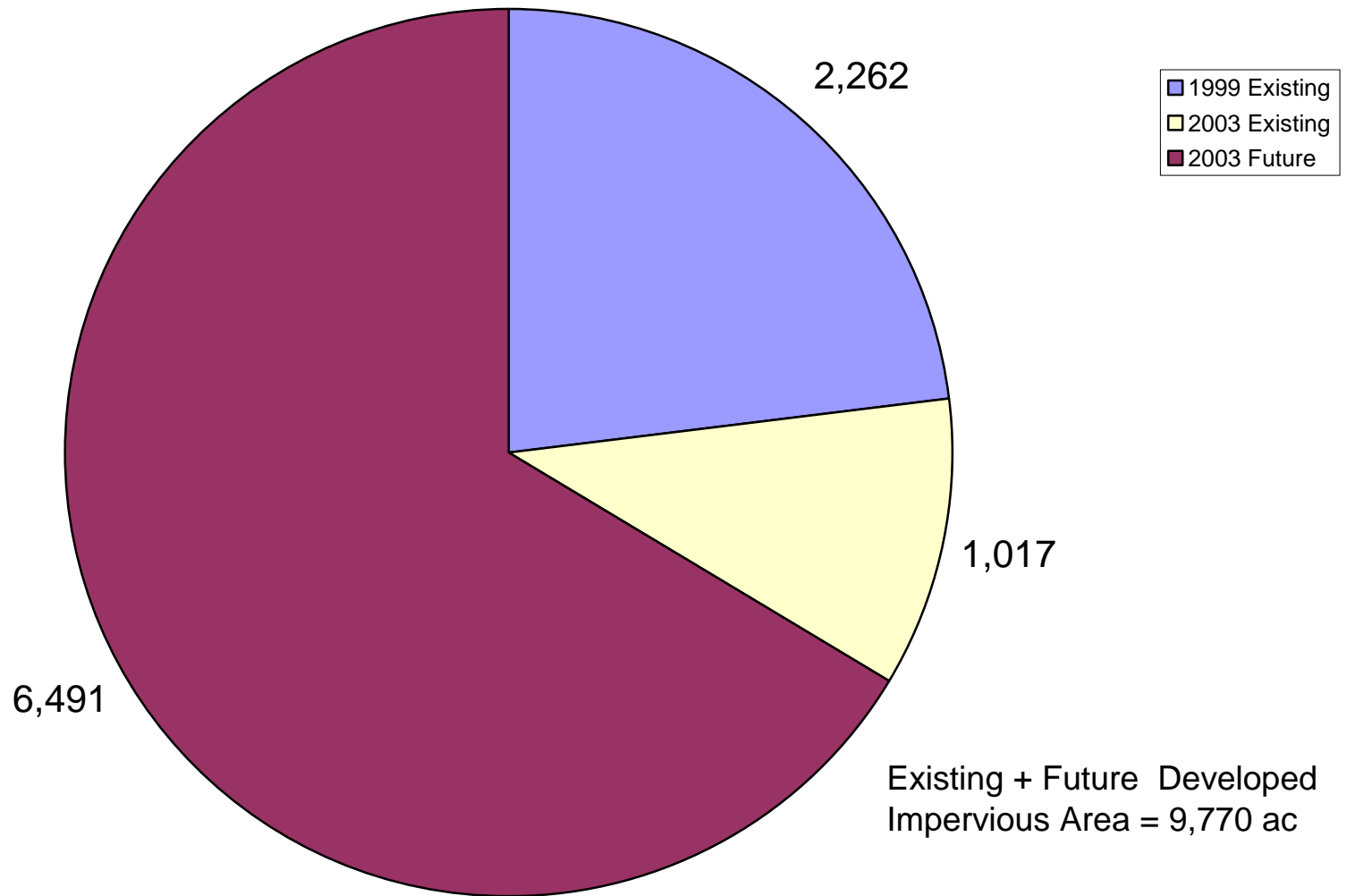- Case 2 requires a reduction of 409 lb/yr

1999 Existing and Future Developed Impervious Area

2,262

7,154

Legend:
- 1999 Existing
- 1999 Future

Existing + Future Developed Impervious Area = 9,416 ac

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2003 Existing and Future Developed Impervious Area

2,262

1,017

6,491

Legend:
- 1999 Existing
- 2003 Existing
- 2003 Future

Existing + Future Developed
Impervious Area = 9,770 ac

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2005 Existing and Future Developed Impervious Area

Legend:
- 1999 Existing
- 2003 Existing
- 2005 Existing
- 2005 Future

2,262

1,017

381

5,027

Existing + Future Developed
Impervious Area = 8,687 ac

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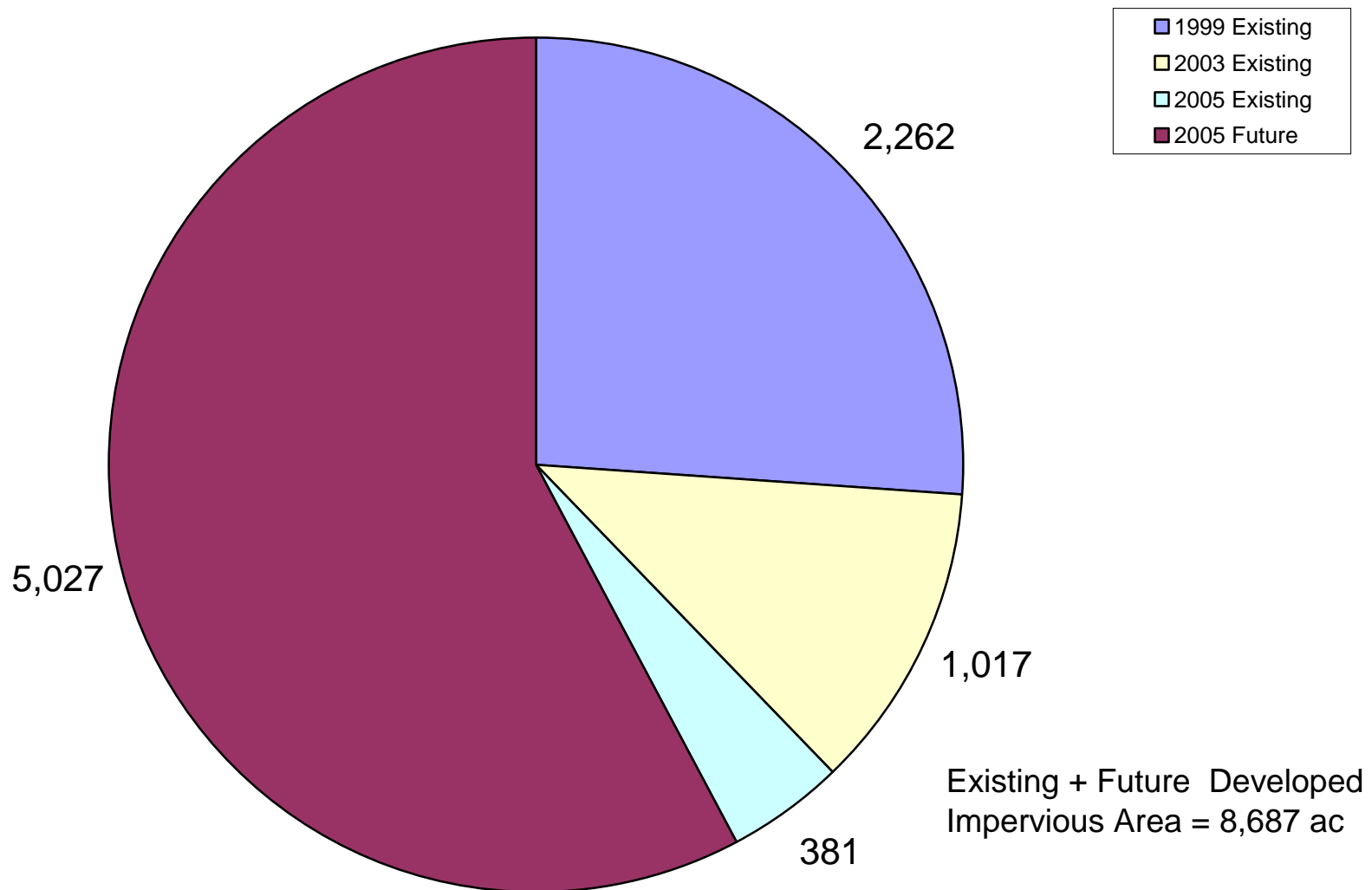
Next Steps – Finalize Revised Watershed Management Plan

- Develop Percent Reduction Goal for Future Development and Determine Load Reduction

- Determine Retrofit Load Reduction Requirement

- Engage Powhatan County

- Develop Non-conventional Stormwater Treatment Design Standards and Design Review Guidance

- Study the Feasibility of Pollutant Trading Options

- Develop Watershed Load/Flow and Reservoir Prediction Tool